ABSTRACTS.

Geological Atlas of the United States. Folio 30, Yellowstone National Park, Wyoming, 1896.

The Yellowstone Park folio, recently issued, consists of six pages of descriptive text, three pages of illustrations, four topographic sheets (scale 1 : 125,000) and four sheets delineating the areal geology of the region.

The general descriptive text, giving a succinct narrative of the geological history and development of the park country from the time of the earliest continental land surfaces up to and including the hydrothermal phenomena as seen today, was written by Arnold Hague, geologist in charge. It is followed by an account of the sedimentary rocks, from the earliest Cambrian deposits to the Tertiary conglomerates, by Walter Harvey Weed, and a brief petrographical description of the igneous rocks, by Joseph Paxson Iddings. The area of country covered by the Yellowstone National Park folio lies between parallels 44° and 45° and meridians 110° and 111°. It is situated in the extreme northwest corner of Wyoming. By far the greater part of the park is included within the area of the four atlas sheets, but a narrow strip lies to the northward in Montana, and a still narrower strip extends westward into Idaho and Montana. In the organic act establishing the park, Congress declared that the reservation was "dedicated and set apart as a public park and pleasure ground for the benefit and enjoyment of the people." Owing to the marvelous display of geysers and hot springs, and such remarkable physical features as the Grand Canyon and Yellowstone Lake, this folio possesses more than ordinary interest to geologists.

The central portion of the Yellowstone Park is a broad volcanic plateau, with an average elevation of 8000 feet, surrounded on nearly all sides by mountains rising from 2000 to 4000 feet above its general level. The continental watershed crosses the park, separating the waters of the Atlantic from those of the Pacific, the Missouri and the Columbia, by the way of the Yellowstone, and the Snake, finding their sources on this plateau.

The oldest rocks of this region are granites, gneisses, and schists regarded as of Archæan age. They occur in all the mountain uplifts that encircle the park, but are unknown in the central portion. Around these ancient continental land masses there was deposited a conformable series of sandstones, limestones, and shales extending from the time of the Middle Cambrian, the lowest beds exposed, through the Upper Cambrian, Silurian, Devonian, Carboniferous, Juratrias, and Cretaceous, including the Laramie sandstone. Nearly all these great divisions of Palæozoic and Mesozoic times are characterized by a typical fauna.

With the close of the deposition of the Laramie sandstone the conformable series of sediments came to an end. The entire region was elevated above the sea, the movement being accompanied with plication and folding of strata. This primary orographic uplift which blocked out the main ranges of the northern Rocky Mountains, has been designated the post-Laramie movement.

Tertiary sedimentary rocks occupy only small areas in the park, the greater part of the region being covered by extensive flows of lava. A heavy mass of coarse conglomerate, designated the Pinyon conglomerate, has been referred to the Eocene; and Pliocene conglomerate and coarse sands are well exposed in the escarpments of the Grand Canyon.

Volcanic energy, which has played so great a part in the geological development of the country, was connected with the post-Laramie movement and followed closely upon the elevation of the mountains, and the accompanying dislocation and compression of strata. The eruptive masses, in forcing their way upward, sought egress along lines of least resistance, or wherever strain has been greatest in the crumpled sediments. Volcanic outbursts continued on a grand scale throughout Tertiary time.

During the Eocene and Miocene periods enormous volumes of fragmental ejectamenta, largely composed of andesitic and basaltic breccias, were thrown out. The Absaroka Range was almost wholly built up of volcanic material. Evidence of this long-continued action is shown in the well-preserved fossil floras of Eocene and both Lower and Upper Miocene age. The famous fossil forests of the Yellowstone are of Miocene age. After a period of great erosion the depressed basin lying between the encircling ranges was transformed into the present Park plateau by the extravasation of immense flows of rhyolite

of Pliocene age. Still later the recent basalts, the last of the igneous extrusions, poured out over the rhyolite along the ridges of the plateau. A generalized vertical section accompanies the text, showing the order of succession of the extrusive flows, from the earliest outbursts to the final dying out of eruptive energy. It is shown that long-continued currents of heated waters and acid vapors have acted as powerful agents in decomposing the igneous rocks of the plateau, and date back to Pliocene time; at least they were active before glacial ice covered the country. Hot springs, geysers, and solfataras are closely associated with the rhyolite, and in fact thermal activity is confined almost exclusively to areas of this rock.

The illustrations relate mainly to the occurrence of both active and dormant geysers and hot springs or some phase of volcanic geology. The Grand Canyon, well shown in the illustration, is a profound gorge cut in the Pliocene rhyolite, the brilliant coloring being due to the action of thermal waters.

Geologic Atlas of the United States. Folio 24, Three Forks, Montana, 1896.

This folio, by Dr. A. C. Peale, consists of five pages of text, a topographic sheet (scale 1 : 250,000), a sheet of areal geology, one of economic geology, one of structure sections, and one giving a generalized columnar section for the district.

The area covered comprises the square degree which lies between the meridians 111° and 112° and the parallels 45° and 46°, in the southwestern, mountainous portion of Montana, and includes 3354 square miles. In the extreme southeast corner the Yellowstone National Park barely falls within the area. The folio derives its name from the valley in which the Jefferson, Gallatin, and Madison rivers unite to form the Missouri. The "Three Forks" valley is important from an historic standpoint, as being the point which Lewis and Clark reached in July, 1805, when they named the three confluent branches of the Missouri.

The text begins with a general description of the geography and topography of the region, and then takes up the general geology. The oldest rocks in the region are the crystalline schists and gneisses, designated as of Archæan age, which in pre-Cambrian time formed a land mass comprising nearly all the area included in the map. While

the Algonkian beds were being deposited to the extent of from 6000 to 12,000 feet, there was a gradual subsidence of the whole region, and shallow seas for the most part prevailed. During the Palæozoic age there were many minor oscillations of the surface, which were more frequent during Cambrian time than during the deposition of the Devonian and Carboniferous limestones. Toward the close of the Cretaceous period a general elevation began, which was accelerated after the deposition of the Laramie formation. The formation of the mountain ranges, together with the subsequent erosion, resulted in many valleys, which eventually were occupied by fresh-water lakes. These lakes attained their greatest extent in the Neocene period, lasting in all probability until the Pleistocene period was well advanced, and during their earlier stages immense bodies of wind-carried volcanic dust were deposited in their waters, and are now seen as beds of pure white. At the same time the dust fell upon the surrounding country, from which it was afterward washed into the lakes, forming an upper series of yellowish and rusty colored beds. These dust showers destroyed both animal and vegetable life, and the remains carried into the lakes were buried in their deposits, where they are now found as fossil bones and opalized and silicified wood.

Under the "Description of Rock Formations" are outlined all the formations from the Archean gneisses up through the Algonkian, Cambrian, Devonian, Carboniferous, Juratrias, Cretaceous, Eocene, Neocene, and Pleistocene. The rocks of more than half of the area are of sedimentary origin, while the crystalline rocks occupy approximately 1000 square miles, the remaining third of the area being covered with igneous materials. Prominent among the latter are the andesitic breccias which form the main part of the Gallatin range, the great porphyritic laccolite occupying the center of the Madison range, and the basaltic plateau which lies west of the Madison valley.

Under the heading "Structural Geology," after a general consideration, the vertical and horizontal movements are discussed, and the development of the lake basins is described. The arrangement of the rock-mass is complex, the structure being complicated by laccolites, dikes, and surface flows of igneous material. Unconformities exist, showing that areas previously raised to land surfaces and worn down have subsided, have been crossed by an advancing shore, and later have passed beneath the sea. The great series of conformable strata is closely folded, and has been pushed up in arches, many of which have been

overturned from the effect of horizontal thrusts. The simple as well as the overturned synclines are marked by areas of Laramie Cretaceous beds, which, at the time of the folding, were the latest and highest of the formations. The arches between the troughs having been broken and exposed by the elevation, excessive erosion has worn them down to the older rocks, exposing the Archæan, which usually forms the axes of the uplifts. Unlike the Appalachian folds, which are strikingly parallel and continuous, these folds lie in various directions, due to several independent centers of uplift. Three great faults cross the Gallatin range, two of them extending across the Madison range to the extreme western part of the area. Following or accompanying the folding of the Cretaceous and pre-Cretaceous strata the detritus resulting from the greatly facilitated erosion, together with volcanic material erupted during this epoch, was deposited unconformably on the eroded upturned edges of the earlier-formed strata.

The lake basins are now the floors of extensive valleys separating the detached mountain ranges, which rise about 6000 feet above their bases. As the lake deposits are at least 2000 feet in thickness, the difference of elevation between the bottoms of the lake basins and the summits of the peaks must be at least 8000 feet. The region was a mountainous one before the development of the lakes, but in the evolution of the existing relief, movements and erosion have both operated to accent the topographic differences.

The principal economic resources of this region are gold, silver, iron ore, copper, limestone, and coal. The occurrence of coal in Devonian rocks on the north side of the Jefferson canyon is of geologic interest, although not of any great economic importance. The fine pumiceous volcanic dust found in the old lake basins has been utilized to a very limited extent as a polishing material. Brick clays occur, and are used to a small extent in a few localities, especially near Bozeman. In addition to the economic resources just referred to, the sheet of economic geology has indicated upon it the localities of building stone and mineral springs.

Geologic Atlas of the United States. Folio 29, Nevada City, special folio, California, 1896.

This folio, by Waldemar Lindgren, consists of seven pages of text, three special topographic maps (scale 1 : 14,400), the Grass Valley,

Nevada City, and Banner Hill; three corresponding maps showing the economic geology, and three others giving structure sections.

These maps, on a scale of about four inches to the mile, have been prepared to illustrate the detailed structure of the gold-mining regions in the vicinity of Nevada City and Grass Valley. Each of them comprises an area three miles wide by four miles long, the total area being nearly thirty-six square miles. The Nevada City and Grass Valley areas fall within the boundaries of the Smartsville atlas sheet, while the larger part of the Banner Hill area falls within those of the Colfax atlas sheet. The relief is that common to the middle foothill region of the Sierra Nevada — that is, the surface is a very irregular and undulating plateau deeply trenched by the canyons of the recent river systems.

Sedimentary rocks, chiefly referred to the Calaveras formation, occupy small, usually long, narrow areas imbedded in the predominating igneous masses. Granodiorite occupies a large part of the Nevada City and Banner Hill districts, while a small *massif* of the same rock is found in the Grass Valley district. Large areas of diabase, porphyrite, and brecciated forms of these rocks surround and separate the granodiorite areas. In the southwestern part of the Nevada City district and the northeastern part of the Grass Valley, a large and complicated *massif* is found, consisting in part of diorite, in part of gabbro, pyroxenite, and serpentine.

The slates of the Calaveras formation are the oldest rocks. Next younger are the diorites, gabbros, and serpentines. Still later are the diabases and porphyrites; and the intrusion of granodiorite closed the succession of igneous rocks. The bed-rock series is, as usual, in part covered by several hundred feet of Neocene gravels, and rhyolitic and andesitic tuffs, the gently sloping top of the andesitic ridges forming a principal feature of the landscape.

The Neocene auriferous gravels have been extensively worked in the Nevada City and Banner Hill districts, both by the drifting and the hydraulic processes, and considerable ground still remains which probably can be profitably worked. The gold-quartz veins are numerous and belong to several distinct systems. They are found in all of the formations represented on the sheet, and generally cross the contacts without change. In the Banner Hill district the veins are narrow but rich, and have a general east-west direction and a northerly or southerly dip. In the Nevada City district the quartz veins have a general north-south direction and an easterly dip of about 45°. Large

dislocations producing overthrust faults have occurred along several of the veins. In the Grass Valley district there is one system with a west-northwesterly direction and a steep northerly or southerly dip. On this system the celebrated Idaho mine is located. Most of the veins in the central and southerly part of the district have a northerly direction and a flat easterly or westerly dip. The veins are often accompanied by strongly developed sheeting of the country rock.

United States Geologic Atlas, Folio 28, Piedmont, West Virginia–Maryland, 1896.

This folio consists of six pages of text, signed by N. H. Darton and Joseph A. Taff, geologists, and closing with a series of vertical sections showing the positions and thickness of the coal beds; a topographic map; a sheet showing the areal geology of the district; another showing the economic geology; a third exhibiting structure sections; and a fourth containing a columnar section and a key to the synonymy of the various formation names. The maps are on a scale of 1:125,000.

The area represented is about 925 square miles. In Maryland it comprises the southern portion of Garret county and a small area in the southwestern corner of Alleghany county. In West Virginia it includes nearly all of Grant county, the western portions of Hardy and Mineral counties, the northeastern portion of Tucker county, and a narrow area of Preston county adjacent to the Maryland boundary line. Its southeastern corner is in a region of Appalachian ridges, and it extends northwestward over the Alleghany Mountains and the Upper Potomac coal basin to the headwaters of the Youghiogheny River, a branch of the Monongahela River.

The geologic formations comprise members ranging from the sandstones in the middle of the Silurian to the Upper Coal Measures of the Carboniferous. In the southeastern portion of the area there are two sharp anticlinal uplifts which bring up the Silurian rocks in two prominent mountains, New Creek Mountain and Patterson Creek Mountain. To the westward lies the coal basin which extends from the Alleghany front to the Backbone Mountain. Along its center is cut the deep gorge of the north branch of the Potomac River. The basin is a relatively shallow one, but it contains about 3000 feet of Carboniferous deposits. To the westward is the anticlinal region of

Devonian rocks which underlie the characteristic glade country about Oakland, Mountain Lake Park, and Deer Park. West of Oakland is another synclinal basin containing about 2500 feet of Carboniferous beds.

The geologic classification does not differ materially from that outlined by W. B. Rogers and others, but geographic names have been applied to all of the formations. The lowest members are a series of sandstones and quartzites, which have been referred to as "No. IV" and "Medina." This series has been subdivided into the Juniata formation, consisting of brownish red sandstones and shales; the Tuscarora quartzite; and the Cacapon sandstones, consisting of thin-bedded red sandstones. Next there is the representative Clinton formation, which has been designated the Rockwood formation, as in other folios; the Lewiston limestones, including representatives of the Helderberg and associated limestones, and the Monterey sandstones, Romney shales, Jennings formation and Hampshire formation, representing the Devonian deposits. As the last three formations are not sharply separated from each other, the patterns by which they are represented on the map are merged in a narrow zone along their boundaries. The Carboniferous period is represented by the Pocono sandstone; the Greenbrier limestone; the Canaan formation, which in a general way is a representative of the Mauch Chunk shales; the Blackwater formation, which represents the Pottsville conglomerate in greater or less part; the Savage formation and Bayard formation, which are the Lower Coal Measures; the Fairfax formation, or Lower Barren Measures, and the Elk Garden formation, a part of the Upper Coal Measures.

The principal coal beds are in the Savage formation, containing the "six-foot" or Davis coal bed; the Bayard formation, containing the coal bed known as the "four-foot" or "three-foot," or "Bayard" or "Thomas" coal; and the Elk Garden formation, containing the "fourteen-foot" coal bed.

On the economic sheet of this folio, the coal-bearing formations are strongly emphasized, and underground contours are introduced to show the lay of the "six-foot" coal bed in the Savage formation for each 100 feet. Other economic resources of the area are red hematite iron ores in thin beds in Rockwood shales and limestones at several horizons, of which the lower member in the Lewiston is locally available for cement.

United States Geologic Atlas, Folio 23, Nomini, Maryland-Virginia, 1896.

This folio consists of four pages of text signed by N. H. Darton, geologist, a topographic map of the district, a map showing the areal geology, and a map showing the distribution of underground waters and artesian wells. The scale of these maps is 1:125,000.

The area represented in this folio is about 938 square miles, which lies partly in Virginia and partly in Maryland. In Virginia it comprises nearly all of Westmoreland county, with parts of Essex, Northumberland, and Richmond, and in Maryland it includes portions of St. Mary, Charles, and Calvert counties. It lies entirely within the Coastal Plain area. The Potomac River extends northwest and southeast across the middle of the area, the Patuxent River crosses its northeastern corner, and the Rappahannock River crosses its southwestern corner. To the extreme northeastward it extends to the shore of Chesapeake Bay. These waters are all tidal estuaries. Along the river valleys there are wide, low terraces capped by the Columbia formation, of Pleistocene age. The intervening areas are plateau remnants capped by Lafayette deposits, of supposed Pliocene age. The underlying formations are the Chesapeake and Pamunkey, the latter extending from the westward only a few miles into the area, along the north side of the Potomac River.

The Pamunkey formation, of which only the uppermost beds are exposed, consist in greater part of glauconitic marls of Eocene age. It is overlain unconformably by the Chesapeake formation, which is characterized by fine sands, marls, and clays, portions of which consist largely of diatomaceous remains. The formation is very fossiliferous at some localities. Its age is Miocene. The greatest thickness which it presents in the Nomini area is about 270 feet, but it continues to thicken gradually to the eastward.

The Lafayette formation, which ranges from 25 to 40 feet in thickness, consists of sandy loams of orange, brown and buff tints often variegated, containing irregularly disposed bands and sprinklings of small quartzite pebbles and coarse sands. The pebbles and larger sand grains are orange tinted, mainly by superficial staining. The plateau surface, capped by this formation and deeply incised and dissected by the larger drainage depressions, inclines gently southeastward at an altitude ranging from about 190 feet along the northern and western border of the area to about 90 feet along its eastern

border. Its greatest altitude is 200 feet in a portion of Nomini cliffs. It has also in most cases a slight slope into each of the river valleys.

The Columbia formation is a deposit of loam merging downward into coarser materials containing beds of quartzite, gravel, and bowlders. Its thickness averages 20 feet. Its surface extends from altitudes of 5 to 60 feet above tide level.

The principal economic features are underground waters, which on the lower lands furnish flows for artesian wells. Three water-bearing horizons are known, one at the base of the Pamunkey, another 100 feet higher in the same formation, and a third in the lower sandy members of the Chesapeake formation. They all dip to the eastward at a very moderate rate. There are many artesian wells which obtain water supplies from 160 to 305 feet. On the artesian well sheet of the folio distinctive underground contours are given to show the depths below tide level of all of the water-bearing horizons.

Other economic resources of the area are marls in the Pamunkey and Chesapeake formations, diatomaceous deposits in the Chesapeake formation which are often sufficiently pure for commercial use, brick clays, potter's clays, sand and gravel.

Geologic Atlas of the United States. Folio 26, Pocahontas, Virginia-West Virginia, 1896.

This folio, by Marius R. Campbell, consists of five pages of text, a topographic sheet (scale 1 : 125,000), a sheet of areal geology, one of economic geology, another of structure sections, and, finally, a sheet giving a generalized columnar section of the district.

The territory mapped and described embraces an area of 950 square miles, the southern portion of which is in Virginia and the northern portion in West Virginia. It is located west of New (Kanawha) River at the place where the state line leaves East River Mountain, the last of the valley ridges toward the northwest, and follows the irregular crests of the ridges within the coal field. The southern portion of this territory is within the limits of the Appalachian valley, and its surface is marked by linear mountains and narrow valleys, which are the characteristic forms of this central division of the Appalachian province. The northern portion is within the Cumberland plateau region, and its surface is that of a tableland deeply dissected, so that it now

presents a confused mass of irregular ridges and hills, only the summits of which reach the original level of the plateau.

The geologic structure of this region varies as the topography varies. In the northern portion the rocks are nearly horizontal, their northwestward slope being rarely more than 200 feet per mile, whereas in the southern portion the rocks have been highly compressed in a horizontal direction, forming huge folds, which in many places have broken, allowing one portion of the fold to slip over the other. It is this tilted condition of the strata which gives rise to the regular topographic forms of the Appalachian valley. The attitude of the rocks is shown on the structure-section sheet by four sections which cross various portions of the territory.

The geologic history of this region is recorded in the rocks, which tell of prevailingly marine conditions from early Cambrian to late Carboniferous time. There were deposited during that time sediments to the extent of 17,000 or 18,000 feet in thickness, which have since been hardened into limestone, shale, and sandstone. Of this great mass the limestones form about 6700 feet; the shales 9500 feet; and the sandstones, about 1400 feet. On lithologic grounds these have been divided into twenty-three separate and distinct formations, which are shown on the general geologic map by various colors and patterns.

There is little variety in the mineral resources of this region. Coal, iron ore, and marble constitute about all of the mineral wealth of the territory. A limited area of coarse gray marble occurs along the northern front of Big Walker Mountain, but no development has been undertaken.

Iron ore occurs in two formations of the Upper Silurian rocks. It is of good quality, and probably in sufficient quantity to be of commercial importance, but its inaccessibility has prevented development.

Coal is by far the most important mineral resource of this region. The territory represented by this sheet embraces almost the entire Flat Top or Pocahontas coal field at present developed. All operations are confined to the great No. III or Pocahontas seam of coal, which is semi-bituminous and ranges in thickness from four to ten feet. It is exposed along the valley of Bluestone River from Pocahontas to the edge of the territory; along Tug Fork; in the valley of Elkhorn Creek from Coaldale to Kimball, near the edge of the area; and at several

places on the head streams of Guyandotte River. Mining is restricted to the Bluestone region and the valley of Elkhorn Creek. In these two areas there are at present in operation thirty-seven distinct mines, which in 1894 produced 3,096,867 long tons of coal.

Geologic Atlas of the United States. Folio 25, Loudon, Tennessee, 1896.

The Loudon folio represents that portion of the Appalachian province which is situated beween the parallels 35° 30′ and 36° and the meridians 84° and 84° 30′. This area contains 968 square miles, divided among Blount, Monroe, Loudon, Knox, Roane and Morgan counties, Tennessee. The folio consists of a topographic map, a geologic map, structure sections, stratigraphic sections, a map of the economic resources, and descriptive text. The author is Arthur Keith.

The text begins with a general description of the Appalachian province, and points out the relations of this area to the general region, with regard to its surface features. The local features of the drainage by the Tennesse River and its tributaries, Emory, Clinch, Tellico, and Little Tennessee, follow next in description. The various forms of surface, such as the great valley of Tennessee and the portions of the mountain district and the Cumberland plateau by which it is bounded, are pointed out, and the relation between these forms and the underlying rocks is made clear.

Under the heading "Stratigraphy," the geologic history of the Appalachian province is presented in outline, and the local rock groups are fully described in regard to composition, thickness, location, varieties, and mode of deposition. The formations, thirty-three in number, range in age from Cambrian, to Carboniferous; being, for the greater part, Cambrian and Silurian. The mountain district is chiefly underlain by the Ocoee series, whose age is doubtful. Rocks of Carboniferous and Devonian age occupy two small belts on either side of the great valley, and Silurian and Cambrian strata are repeated in narrow belts along it. Limestones, shales, and interbedded sandstones make up the Silurian and Cambrian strata; sandstones and shales with coal seams and a limestone near the base constitute the Carboniferous; and the Ocoee rocks are conglomerates, sandstone, slate, and limestone.

The details of the strata are graphically represented in the colum-

nar section. The different manners in which the formations decay is discussed, and the dependence of the residual soils and surface forms on the nature of the underlying rock is brought out. Great lithologic changes occur in the formations of this region, and the Knox dolomite is the only one which is uniform throughout. The direction of change was exactly reversed between Cambrian and Silurian times.

In the discussion of "Structure," after a general statement of the broader features of the province, two processes by which the strata of this quadrangle were deformed are noted. Of these the extreme Appalachian folding accompanied by faulting and metamorphism is by far the more prominent and is about equally developed throughout the quadrangle. Faults, especially, are most strikingly exhibited here. Deformation by vertical uplift is also exhibited, but it is only noticeable in comparison with broad surrounding areas. In this quadrangle the great valley is at its narrowest, on account of the extreme shortening in deformation. The structure sections illustrate the sharp folds and frequent faults into which the strata were forced. Economic products of this region are coal, variegated marble, red hematite, building stone, lime, clays, slate and timber. The outcrops of the formations containing these are indicated on the economic sheet, together with the locations of the mines and quarries. The iron ore and slate are at present of minor importance. The coal district is a part of the great coal basin of Tennessee, and the marble belts are a part of the principal productive region for that stone. Various conditions affecting the value of these deposits are pointed out, and the associations and availability of the building materials and timbers are discussed.

Geologic Atlas of the United States. Folio 27, Morristown, Tennessee, 1896.

The Morristown folio by Arthur Keith, deals with that portion of the Appalachian province which is situated between the parallels 36° and 36° 30′ and the meridians 83° and 83° 30′. This area contains 963 square miles, divided among the counties of Green, Cocke, Jefferson, Hamblen, Grainger, Claiborne, Hancock, and Hawkins, all in Tennessee. Included in the folio are topographic, economic, and geologic maps, structure and stratigraphic sections, and five pages of descriptive text.

After a description of the broader features of the Appalachian province, the local geography is analyzed. The various types of surface features are pointed out, and their relations to the underlying rocks are shown. Local phenomena such as elevations and the details of the drainage which is effected by the Nolichucky, French, Broad, Holston, and Clinch rivers, tributaries of the Tennessee, are detailed.

Under the heading "Stratigraphy" the geologic history of the Appalachians is presented in outline. This is followed by a detailed account of the local rock groups, in regard to their location, composition, thickness, variations, and mode of deposition. The soils and forms of surface produced by each formation are discussed with the formations. Twenty formations ranging from Cambrian to Carboniferous, are distinguished in this quadrangle; the greater portion being Cambrian and Silurian. The rocks of Carboniferous and Devonian age are found only in two narrow belts in the ridge district, and are represented by only four formations. Over the rest of the area Cambrian and Silurian strata are about equally represented. A great variety of limestones, shales, and sandstones compose the Cambrian and Silurian rocks. Shales and sandstones make up the Devonian, while only the limestone appears in the Carboniferous. Great changes take place in the Silurian strata; limestones on the northwest being represented by shales and sandstones at the southeast. The general character of the formations is graphically represented in the columnar sections, one being drawn for each of the two chief geologic districts.

In the discussion of structure, after a general statement of the broader features of Appalachian structure, the two types of deformation shown in this region are described, and illustrations are pointed out in the structure sections. In the ridge district the most prominent feature is the faulting, which has cut the strata into long narrow blocks and produced the characteristic ridge topography. Southeast of Holston River the rocks were deformed by close folds. Deformation by vertical uplift is also present, but it can only be observed in comparison with other and larger areas. In the structure sections, most of the details of the different structures are shown.

Economic products of this region are marble, building stone, lead, zinc, cement, clays, and timber. The outcrops of the formations containing these are represented on the economic sheet as far as possible, together with the locations of mines and quarries. The principle

industries are the production of zinc and marble; the timbers and water powers are also of general importance. The various conditions which affect the development of these resources are discussed.

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